

KTeV Meeting
March 12, 2005

Status of
 $K_L \rightarrow \pi^+ \pi^- \pi^0 e^+ e^-$
and
 $K_L \rightarrow \pi^+ \pi^- \pi_D^0 \gamma$

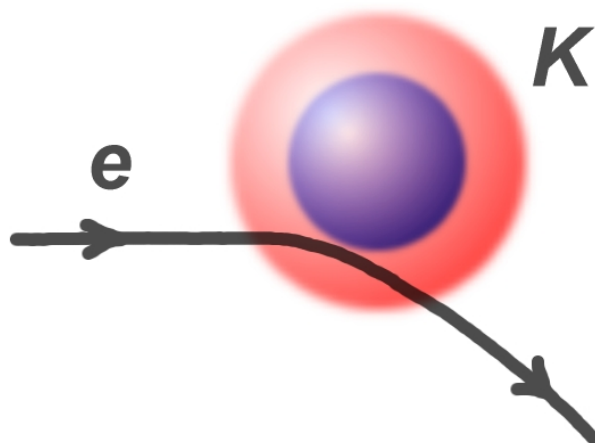
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Neutral Kaons have
charge structure.

*we have measured non-zero
 K^0 charge radius*

Electrons scatter off a
neutral Kaon when
“inside” of it



what happens to a neutral kaon?

Before scattering: pure K_L

After scattering: mixture of K_L and K_S

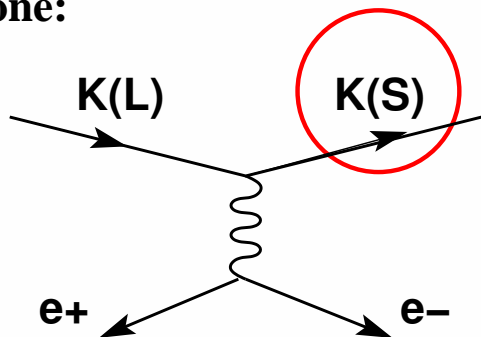
motivation (cont'd)

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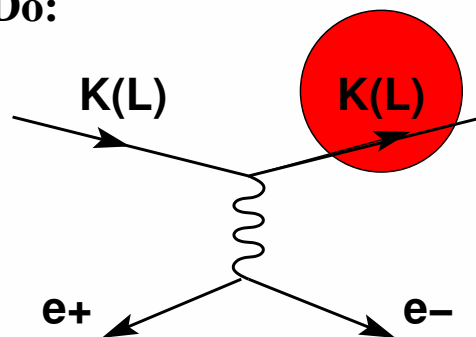
We measured $K_S \rightarrow \pi^+ \pi^-$ final state in $K_L \rightarrow \pi^+ \pi^- e^+ e^-$

We set upper limit for $K_S \rightarrow \pi^0 \pi^0$ final state in $K_L \rightarrow \pi^0 \pi^0 e^+ e^-$

Done:



ToDo:



The **goal** is to measure $K_L \rightarrow \pi^+ \pi^- \pi^0$ final state in $K_L \rightarrow \pi^+ \pi^- \pi^0 e^+ e^-$ and $K_L \rightarrow \pi^0 \pi^0 \pi^0$ final state in $K_L \rightarrow \pi^0 \pi^0 \pi^0 e^+ e^-$

'97 DATA has been crunched with KTEVANA V6.01.

The crunch output includes:

Normalization mode: $K_L \rightarrow \pi^+ \pi^- \pi_D^0$, prescaled $\times 16$

Signal mode: $K_L \rightarrow \pi^+ \pi^- \pi_D^0 e^+ e^-$

Cross-check mode: $K_L \rightarrow \pi^+ \pi^- \pi_D^0 \gamma$

Double decay normalization: Events with 6 or more tracks

Analysis cuts, common for all modes are:

4 track vertex. No extra tracks

$E/p \leq 0.9$ for pions

$0.9 \leq E/p \leq 1.1$ for electrons

$\pi^+\pi^-e^+e^-$ topology for tracks

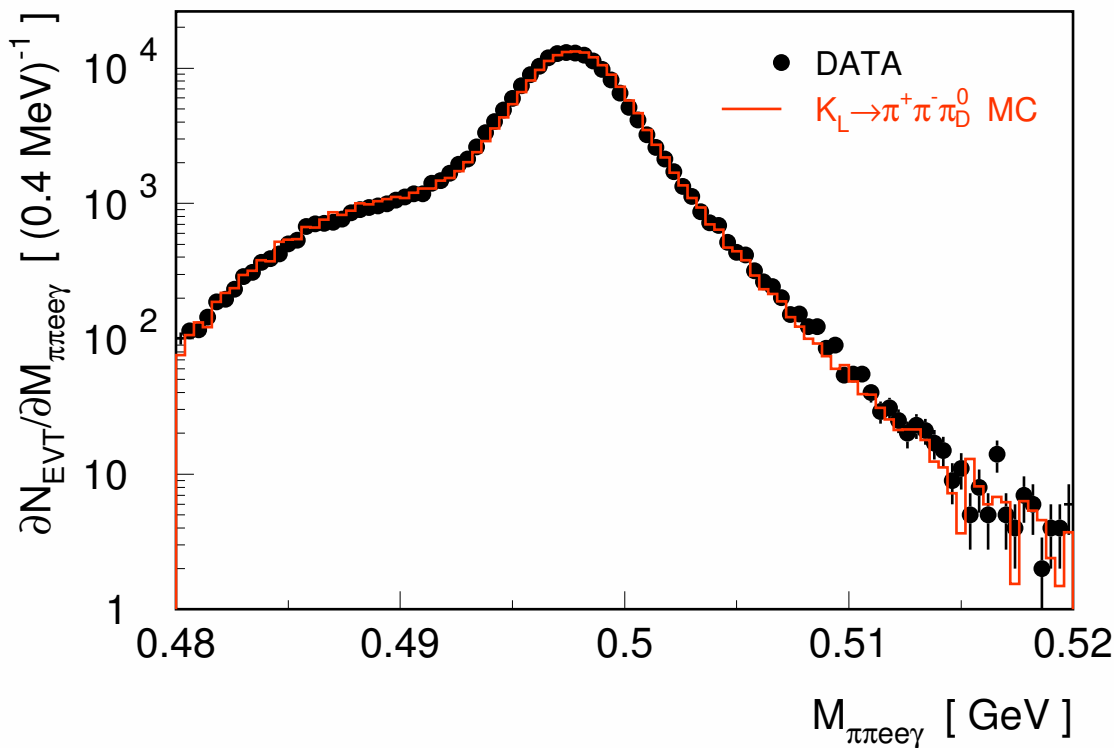
4TRK trigger verified

BAD SPILL mask is not set (disregard TRD)

$M(e^+e^-) \geq 0.002$

$K_L \rightarrow \pi^+ \pi^- \pi_D^0$ is also a largest source of background. MC sample is generated with V5.06

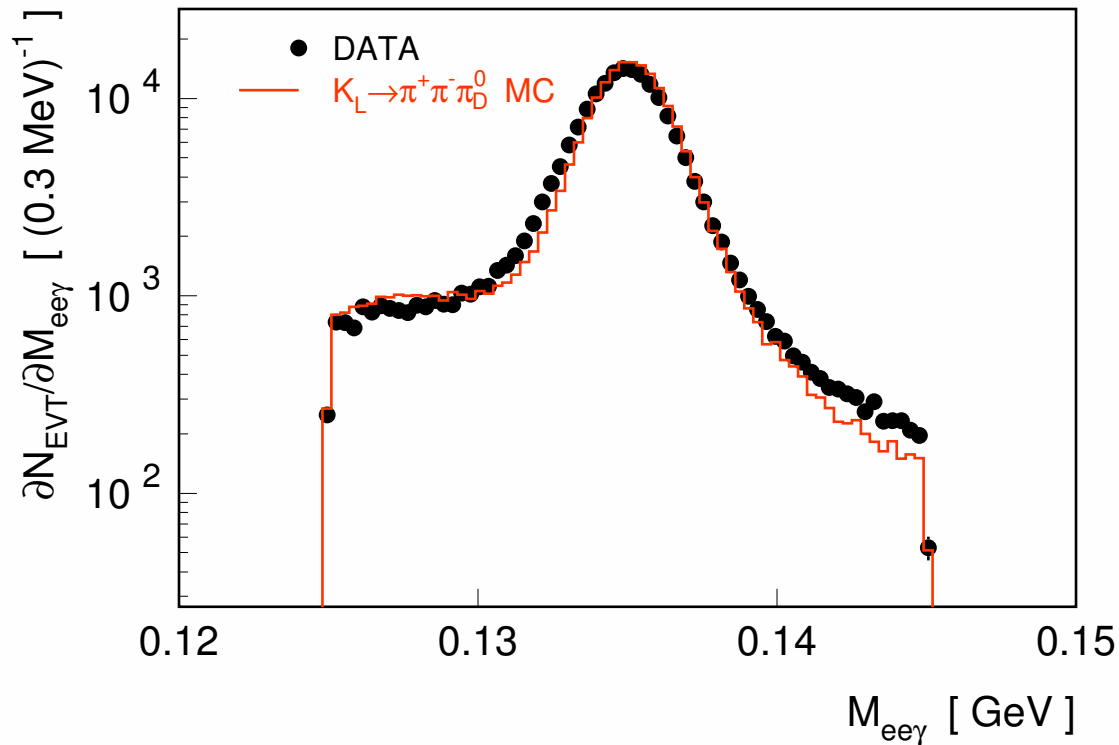
MC = $1.34 \times$ DATA



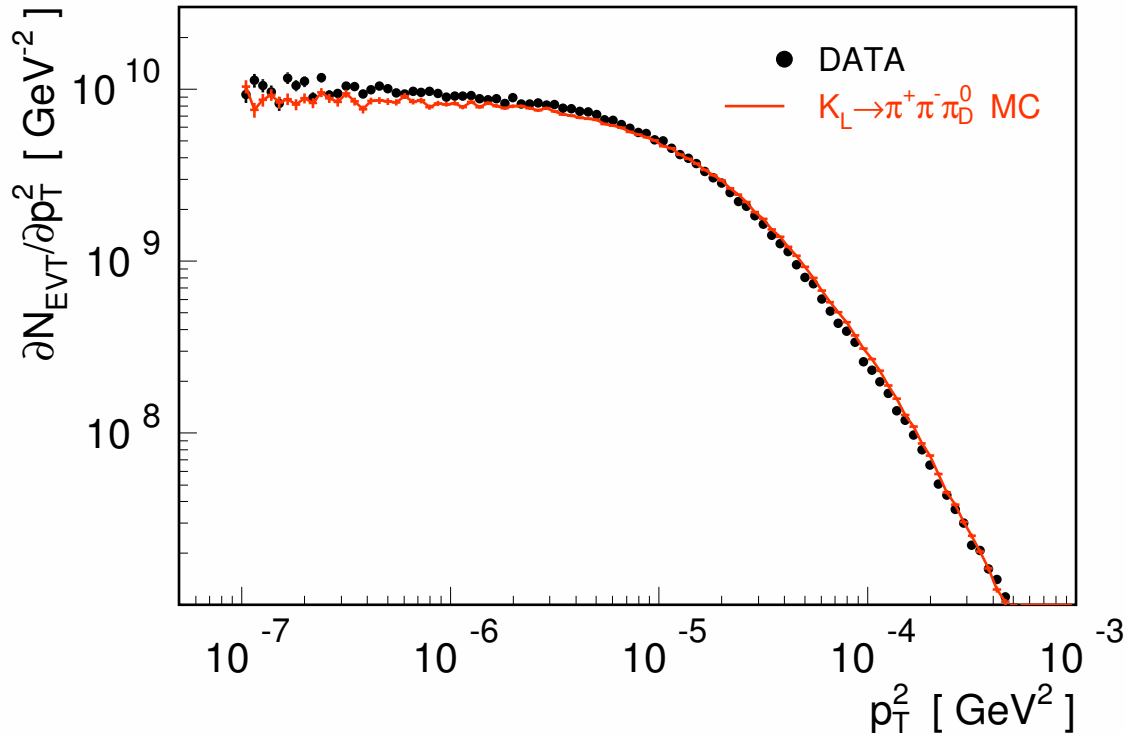
normalization mode (cont'd)

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Invariant mass of $e^+e^-\gamma$ for $K_L \rightarrow \pi^+\pi^-\pi_D^0$ events



Distribution of P_T^2 for $K_L \rightarrow \pi^+ \pi^- \pi_D^0$ events



MC generated sample of $K_L \rightarrow \pi^+ \pi^- \pi_D^0$ is $\times 1.34$ of DATA sample ('97 run only). It will be used as a normalization.

It is also a major source of background.

all signal distributions in this talk show this background, normalized to the flux

DATA/MC agreement was studied in a great number of distributions. In general, the agreement is good. But some MC limitations were discovered.

I will discuss it in the future along with systematics

$K_L \rightarrow \pi^+ \pi^- \pi^0 e^+ e^-$ cuts are:

Common cuts for normalization and signal modes and at least 1 pair of photon clusters that:

are HW clusters

$$0.12 \leq M(\gamma\gamma) \leq 0.15$$

$$0.47 \leq M(\pi\pi\gamma\gamma ee) \leq 0.57$$

$$P_T^2 \leq 0.0005$$

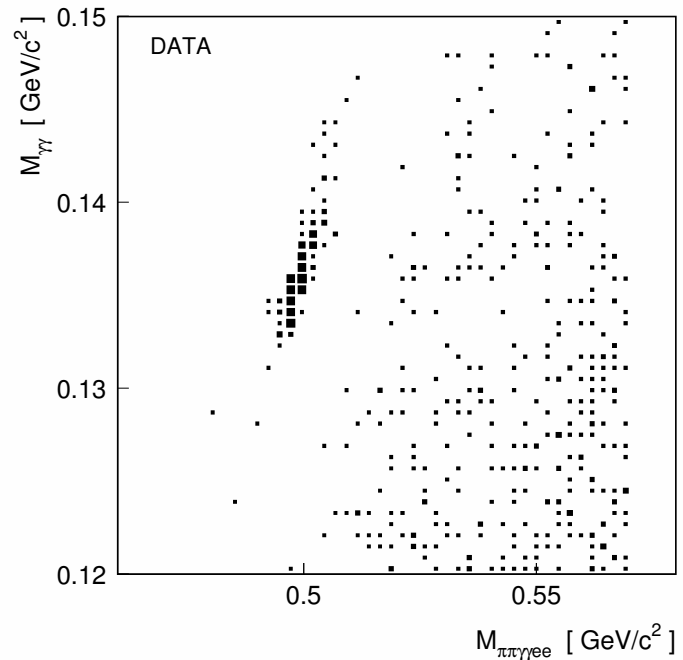
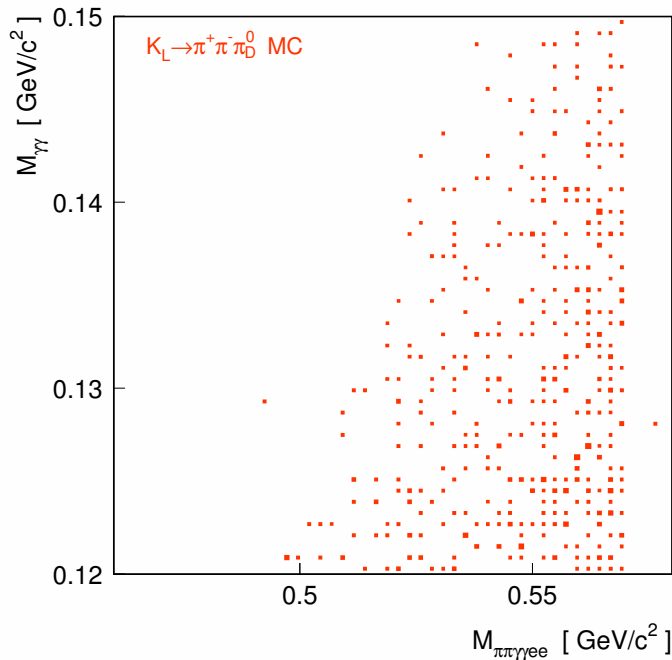
$$M(e^+e^-\gamma) \leq 0.125 \text{ or } M(e^+e^-\gamma) \geq 0.145$$

not an external brem (more later)

signal mode (cont'd)

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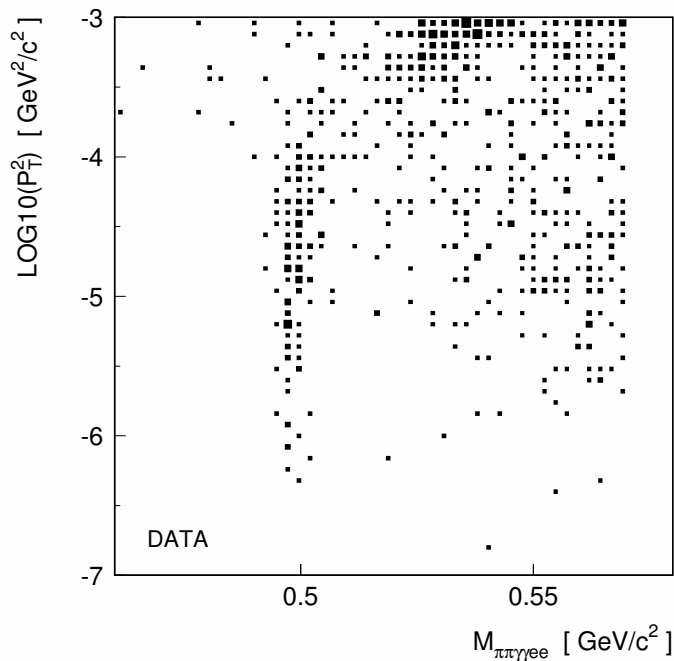
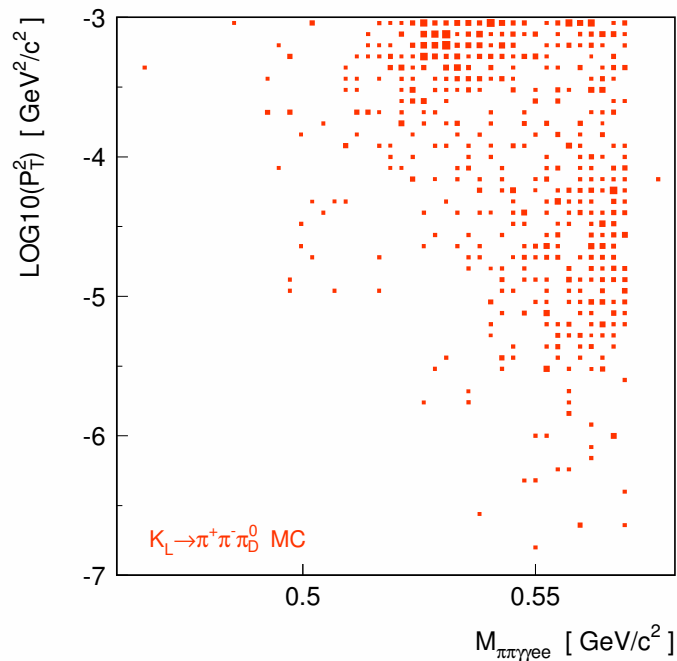
Invariant mass of $\gamma\gamma$ vs invariant mass of $\pi^+\pi^-\gamma\gamma e^+e^-$ for $K_L \rightarrow \pi^+\pi^-\pi^0 e^+e^-$ candidates. Left (red) is background MC. Right (black) is '97 DATA.



signal mode (cont'd)

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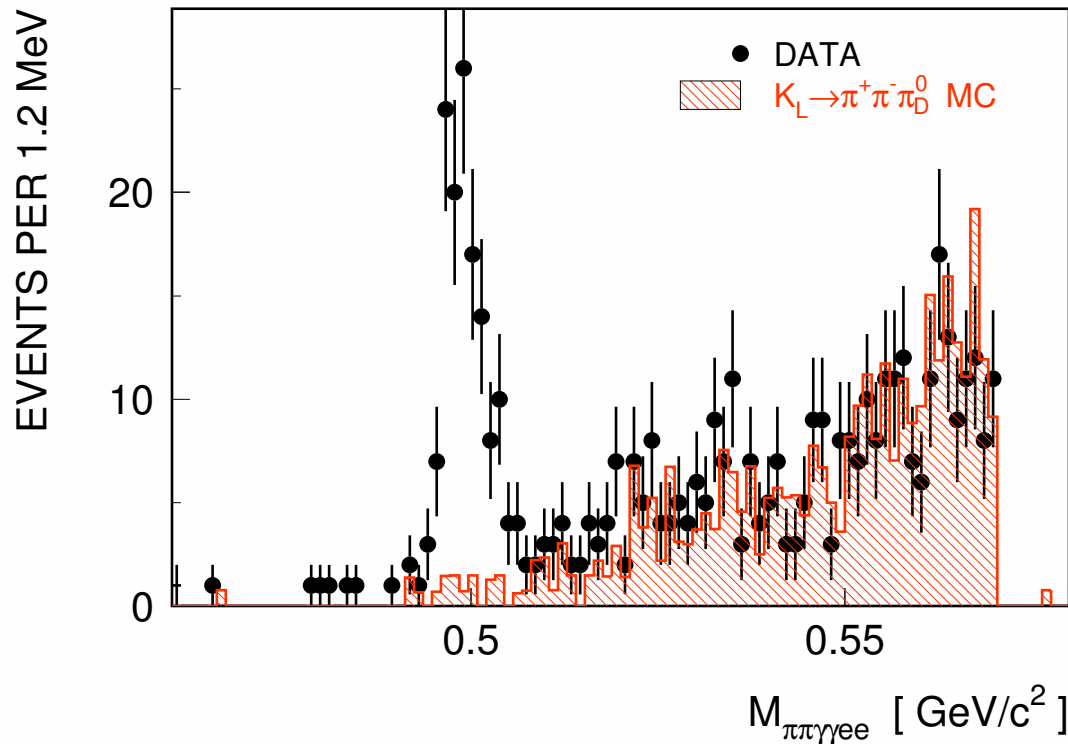
$\log_{10}(P_T^2)$ vs $\pi^+\pi^-\gamma\gamma e^+e^-$ invariant mass for $K_L \rightarrow \pi^+\pi^-\pi^0 e^+e^-$ candidates. Left (red) is background MC. Right (black) is '97 DATA.



signal mode (cont'd)

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$\pi^+\pi^-\gamma\gamma e^+e^-$ invariant mass for $K_L \rightarrow \pi^+\pi^-\pi^0 e^+e^-$ candidates. Black dots are '97 DATA. Red histogram is simulated $K_L \rightarrow \pi^+\pi^-\pi_D^0$ background.



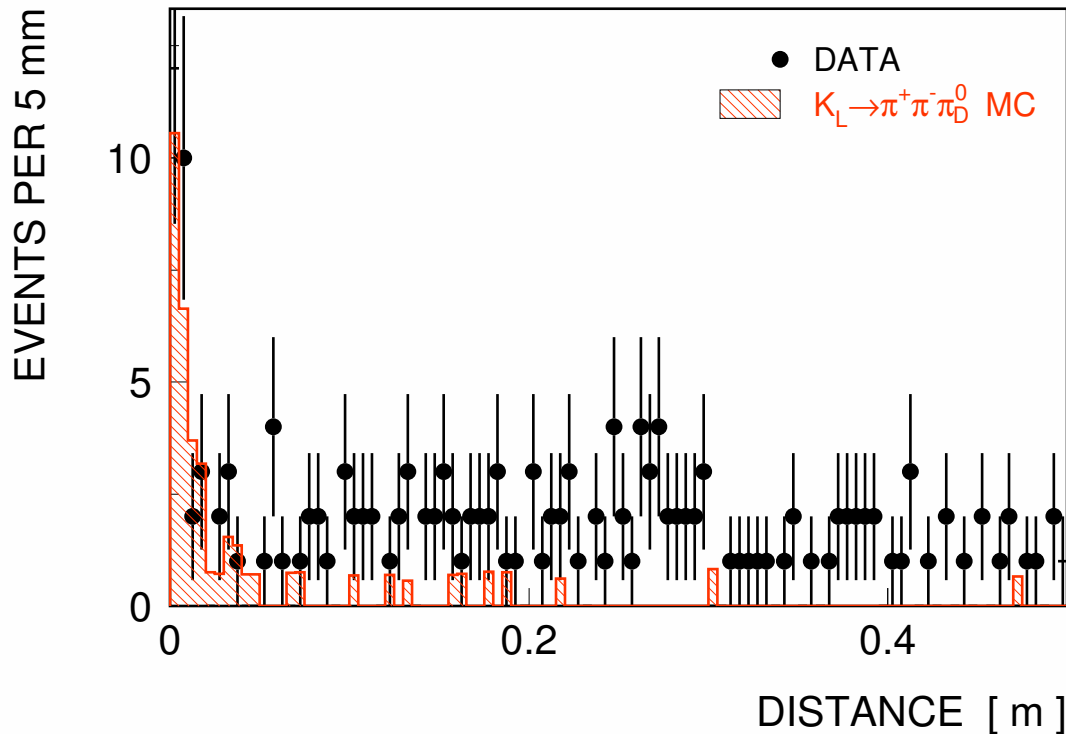
Cuts are not finalized yet. I can observe from ~ 100 to ~ 200 events in the signal peak with different sets of cuts.

I would like to generate other backgrounds and signal MC for cut optimization

external brem cut for signal

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Distance from photon cluster to upstream segment of electron track, projected onto CsI plane. Cut value is 2 cm.



$K_L \rightarrow \pi^+ \pi^- \pi_D^0 \gamma$ cuts are:

Common cuts for normalization and signal modes and at least 1 pair of photons that:

are HW clusters

$$0.13 \leq M(e^+ e^- \gamma_1) \leq 0.14 \text{ and } E_{\gamma_2} \geq 2.0$$

$$0.47 \leq M(\pi\pi ee\gamma\gamma) \leq 0.53$$

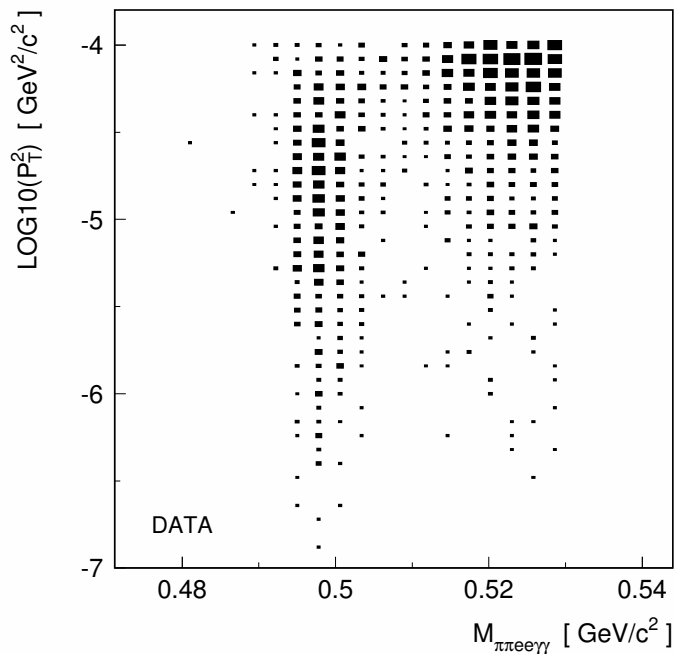
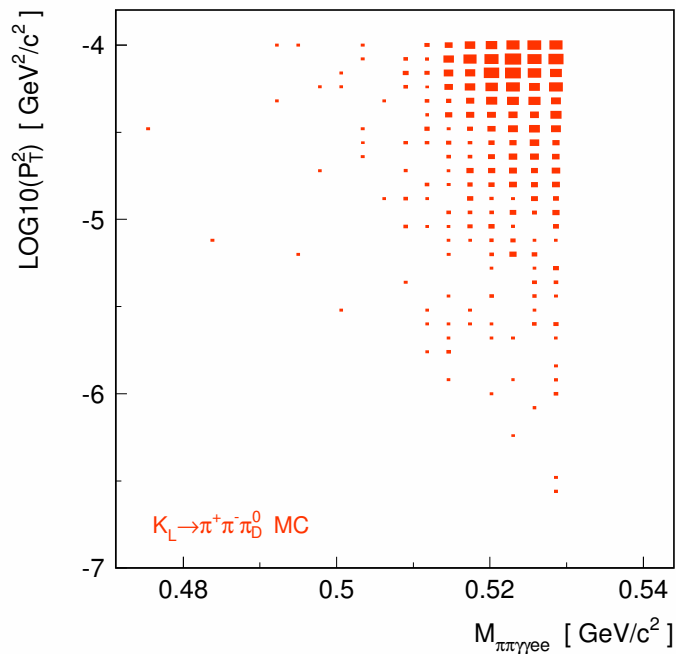
$$P_T^2 \leq 0.0001$$

$$M(e^+ e^- \gamma\gamma) \geq 0.15$$

cross-check mode (cont'd)

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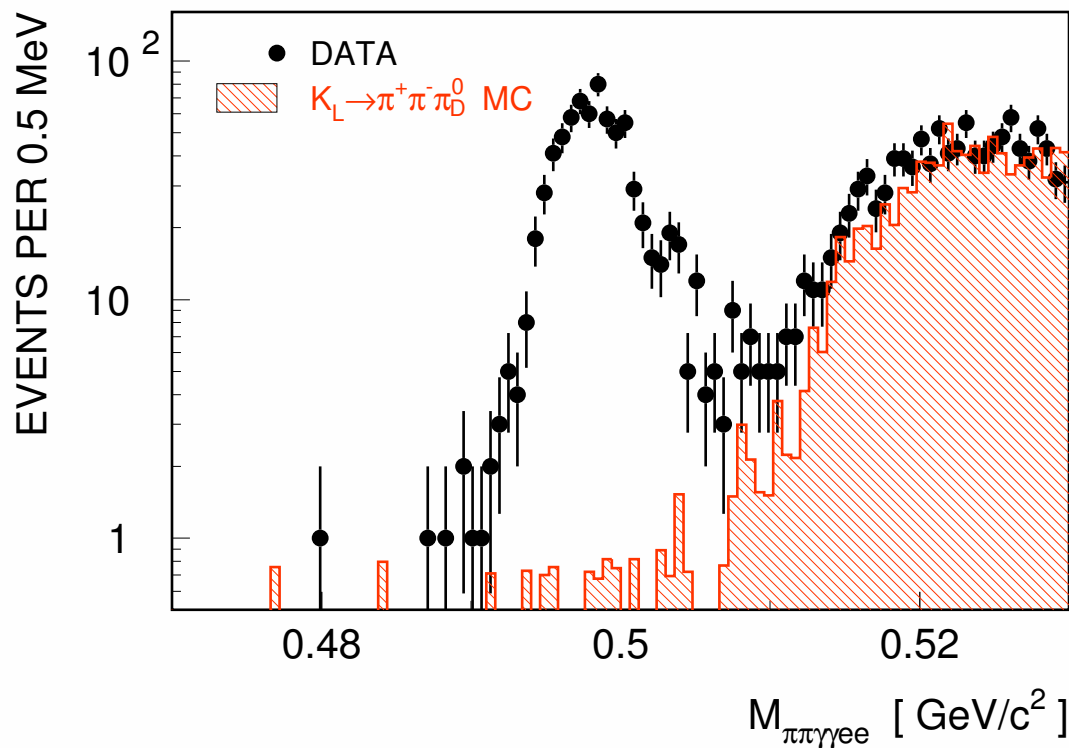
$\log_{10}(P_T^2)$ vs $\pi^+\pi^-e^+e^-\gamma\gamma$ invariant mass for $K_L \rightarrow \pi^+\pi^-\pi_D^0\gamma$ candidates. Left (red) is background MC. Right (black) is '97 DATA.



cross-check mode (cont'd)

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$\pi^+\pi^-e^+e^-\gamma\gamma$ invariant mass for $K_L \rightarrow \pi^+\pi^-\pi_D^0\gamma$ candidates. Black dots are '97 DATA. Red histogram is simulated $K_L \rightarrow \pi^+\pi^-\pi_D^0$ background.



Cuts are not finalized yet. I can observe from ~ 1000 to ~ 3000 events in the signal peak with different sets of cuts.

There is a type of background other than

$$K_L \rightarrow \pi^+ \pi^- \pi_D^0$$

I would like to generate other backgrounds and signal MC for cut optimization

'97 DATA has been crunched. Both signal and cross-check modes are observed. We can expect few hundreds of $K_L \rightarrow \pi^+ \pi^- \pi^0 e^+ e^-$ and few thousands of $K_L \rightarrow \pi^+ \pi^- \pi_D^0 \gamma$

Need to finish generating MC backgrounds and signal MC for '97 run. Optimize analysis cuts. Develop strategy for measuring charge radius amplitude. Proceed with '99 crunch.

Search for $K_L \rightarrow \pi^0 \pi^0 \pi^0 e^+ e^-$ and $K_L \rightarrow \pi^0 \pi^0 \pi_D^0 \gamma$